CLAIMS

We claim:

1. A method of computer generation of an interactive virtual reality world for monitoring and/or controlling a process that is physical or computational, comprising:

constructing a first group of one or more related screen displays associated with the operation of an industrial or commercial process, which screen displays, called raw data views, are analog representations or alphanumeric equivalents of outputs from at least two signal interfaces of equipment or of variables in the industrial or commercial process that is to be monitored, controlled, or simulated;

constructing a second group of one or more related screen displays associated with the operation of an industrial or commercial process, which screen displays, called derived views, include visual representations, called output objects, of one or more processing variables or of one or more units of processing equipment in the industrial or commercial process that is to be monitored, controlled, or simulated, which output objects are derived from outputs from analog or digital signal output, or from analog or digital sensor interfaces of equipment or of variables in the industrial or commercial process that is to be monitored, controlled, or simulated;

constructing in the derived views one or more visual representations, called input objects, of controllable elements, if any, in the industrial or commercial process that is to be controlled or simulated, which input objects include visual representations of adjustable parameters, called control elements, associated with an analog or digital signal

input interface of a controllable element of a unit of equipment or of a computational module in the industrial or commercial process that is to be controlled or simulated;

interfacing the input objects, including the control elements thereof, with the corresponding inputs of signal interfaces of equipment or of variables in the industrial or commercial process that is to be controlled or simulated so that changing the control elements through manipulation by mouse, keyboard command, or by other input device associated with the computer displaying a derived view, a value or state of a control element in an input object causes a corresponding change in the analog or digital signal presented at the corresponding signal input interface of a unit of equipment or of variables or of a computational module in the industrial or commercial process that is to be controlled or simulated;

controlling a unit of equipment or of a computational module in the industrial or commercial process through manipulation of the control elements; and

interfacing through communications circuits or network one or more interactive virtual worlds with a human or cyber user of the one or more interactive virtual worlds.

2. The method of claim 1, wherein the interactive virtual world includes a means whereby the user of the interactive virtual worlds can select what output objects or input objects to display in a view.

3. The method of claim 1, wherein each output object in one series of derived views corresponds to a specific piece of equipment, a specific computational module, or a variable of interest in the industrial or commercial process that is to be monitored, controlled, or simulated, and wherein the collection of such derived views, called herein a process overview

world, shows output objects related to each other according to a chronologically based sequence, such as the sequence in which a workpiece is handled, a feedstream is processed, a computational process is executed, a customer is serviced, or according to another.

4. The method of claims 1, 2, or 3, wherein each control element of an input object corresponds to a single processing variable in the industrial or commercial process that is to be controlled or simulated.

5. The method of claims 1, 2, or 3, wherein each control element of an input object corresponds to at least two processing variables in the industrial or commercial process that is to be controlled or simulated.

6. The method of claims 1, 2, or 3, wherein the computer displaying an interactive virtual reality world, or a computer interfaced over a communications network with the computer displaying an interactive virtual reality world, includes a means for rendering the derived views in two dimensions.

7. The method of claims 1, 2, or 3, wherein the computer displaying an interactive virtual reality world, or a computer interfaced over a communications network with the computer displaying an interactive virtual reality world, includes a means for rendering the derived views in three dimensions.

8. The method of claims 1, 2, or 3, wherein the computer displaying an interactive virtual reality world, or a computer interfaced over a communications network with the computer displaying an process overview world, includes a means for rendering the derived views in three dimensions, and wherein the user can navigate the user's point of observation to any point within the coordinate space of the interactive virtual reality world and obtain a display of a three-dimensional perspective view from such point of observation.

9. The method of claims 1, 2, or 3, wherein the computer displaying an interactive virtual reality world, or a computer interfaced over a communications network with the computer displaying an interactive virtual reality world, includes a means for rendering the derived views in the interactive virtual reality world in three dimensions, and wherein the perspectives in the derived views can be moved by the user through a unit of equipment or through a computational module to display an "x-ray vision" view of the internal aspects of a unit of equipment, of a workpiece being handled, of a feedstream being processed, or a computational process being executed.

10. The method of claim 3, wherein the computer displaying a process overview world, or a computer interfaced over a communications network with the computer displaying a process overview world, includes a means for storing limit values of parameters of a signal output interface, and of detecting and displaying that a parameter of a signal output interface associated with an output object has exceeded one or more limit values, and during periods a parameter of a signal output interface associated with an output object has exceeded one or more limit values, displaying a notice, called an alarm window, that describes each parameter

and parameter value that has exceeded one or more limit values, wherein such display is adjacent to the relevant output object in user's display screen or in another part of the user's display screen and is in schematic form, in symbolic form, or as alphanumeric data.

11. The method of claim 10, wherein the computer displaying a process overview world, or a computer interfaced over a communications network with the computer displaying a process overview world, includes a means for computing, and for storing and displaying, the results of root cause analysis of parameters exceeding limit values, and during periods a parameter of a signal output interface associated with an output object has exceeded one or more limit values, the results of computing root cause analysis pertaining to a parameter of a signal output interface associated with an output object that has exceeded one or more limit values are displayed in symbolic or schematic form or as alphanumeric data in the alarm window, adjacent to the associated output object, or in another area of the user's display screen.

12. The method of claim 10, wherein the computer displaying a process overview world, or a computer interfaced over a communications network with the computer displaying a process overview world, includes a database containing information about each root cause analysis that is performed and includes a means for displaying a visual representation or alphanumeric data to a user of the computer displaying a process overview world, and upon request from the user to display additional information about the result of a root cause analysis, displays such additional information to the user in symbolic or schematic form or as alphanumeric data.

13. The method of claim 3, wherein the computer displaying a process overview world, or a computer interfaced over a communications network with the computer displaying a process overview world, includes a means for predicting that parameters of one or more units of equipment or of computational modules associated with an output object have reached a threshold probability of exceeding limit values, wherein such computer stores and displays the identity of the parameters and the results of the prediction as a visual representation or as alphanumeric data in an area, called a prediction window, adjacent to the associated output object displayed in a user's display screen, or in another area of the user's display screen.

14. The method of claim 3, wherein the computer displaying a process overview world, or a computer interfaced over a communications network with the computer displaying a process overview world, includes a means for determining unused capacity of one or more units of equipment or of computational modules associated with an output object, and of storing the results of the determination, wherein such computer stores and displays the identity of the parameters involved and the results of the determination as a visual representation or as alphanumeric data in an area, called a capacity window, adjacent to the associated output object displayed in a user's display screen, or in another area of the user's display screen.

15. The method of claim 3, wherein the computer displaying a process overview world, or a computer interfaced over a communications network with the computer displaying a process overview world, includes a means for determining how existing capacity of one or more units of equipment or of computational modules might be used more efficiently, wherein such computer stores and displays the results of the determination as a visual representation or as

alphanumeric data in an area, called an efficiency window, adjacent to the associated output object displayed in a user's display screen, or in another area of the user's display screen.

16. The method of claim 1, wherein one series of derived views, called herein a variable interaction world, includes output objects, input objects, and views in which the output objects and input objects are included in a given view based on interdependencies among the variables that the output objects and input objects represent.

17. The method of claim 16, wherein the variable interaction world includes:

a means for rendering the derived views in three dimensions, and wherein the user can navigate the user's point of observation to any point within the coordinate space of the variable interaction world and obtain a display of a three-dimensional perspective view from such point of observation;

a means of computing and displaying interdependencies among the variables that the output objects and input objects in a view represent;

visual representations in schematic form, in symbolic form, or as alphanumeric data that show the interdependencies;

a means for storing limit values of parameters of a signal output interface, and of detecting and displaying that a parameter of a signal output interface associated with an output object has exceeded one or more limit values, and during periods a parameter of a signal output interface associated with an output object has exceeded one or more limit values, displaying a notice, called an alarm window, that describes each parameter and parameter value that has exceeded one or more limit values, wherein such display is adjacent to the relevant output object

in user's display screen or in another part of the user's display screen and is in schematic form, in symbolic form, or as alphanumeric data; and may include

a means for predicting that parameters of one or more variables in the variable interaction world have reached a threshold probability of exceeding limit values, and for display of the identity of the variables and the results of the prediction as a visual representation or as alphanumeric data in an area, called a prediction window, adjacent to the associated output object displayed in a user's display screen, or in another area of the user's display screen.

18. The method of claim 16, wherein the output objects and input objects in a view within the variable interaction world are included in a given view based on the criticality of the variables represented by the output objects and input objects in the industrial or commercial process that is to be monitored, controlled, or simulated.

19. The method of claim 1, wherein one series of derived views, called herein a detailed derivation world, includes output objects and input objects and:

a means for rendering the derived views in three dimensions, and wherein the user can navigate the user's point of observation to any point within the coordinate space of the detailed derivation world and obtain a display of a three-dimensional perspective view from such point of observation;

views in which the output objects and input objects are included in a given view based on the interdependencies among the variables that the output objects and input objects represent;

a means of computing and displaying a calculation or other derivation of the variables associated with the output objects and input objects;

visual representations in schematic form, in symbolic form, or as alphanumeric data that show the calculation or other derivation of the variables associated with the output objects and input objects;

a means for storing limit values of parameters of a signal output interface, and of detecting and displaying that a parameter of a signal output interface associated with an output object has exceeded one or more limit values, and during periods a parameter of a signal output interface associated with an output object has exceeded one or more limit values, displaying a notice, called an alarm window, that describes each parameter and parameter value that has exceeded one or more limit values, wherein such display is adjacent to the relevant output object in user's display screen or in another part of the user's display screen and is in schematic form, in symbolic form, or as alphanumeric data; and may include

a means for predicting that parameters of one or more variables in the detailed derivation world have reached a threshold probability of exceeding limit values, and for display of the identity of the variables and the results of the prediction as a visual representation or as alphanumeric data in an area, called a prediction window, adjacent to the associated output object displayed in a user's display screen, or in another area of the user's display screen.

20. A method of computer generation of an interactive virtual reality world for monitoring and controlling a process that is physical or computational, comprising:

constructing a raw data world;

constructing a process overview world;

constructing a variable interaction world;

constructing a detailed derivation world;

providing a user with a means of navigating the collection of worlds by selecting an output object and following the output object's links to other worlds, or by selecting an input object and following the input object's links to other worlds;

displaying views in the other worlds; and

enabling the use to drill-up, drill-down, and drill-across through worlds.

21. A system for conveying information to a user through a display of a three-dimensional world, comprising:

receiving data from at least two data sources;

transforming the data from each data source into a three-dimensional graphical object;

presenting each graphical object to the user within the three-dimensional world;

generating a processed set of data from at least one source of data;

transforming the processed set of data into a processed data graphical object; and

presenting the processed data graphical object in the three-dimensional world.

22. A system for the computer generation of an interactive virtual reality world for process control comprising:

a means for constructing a first group of one or more related screen displays associated with the operation of an industrial or commercial process, which screen displays, called raw data views, are analog representations or alphanumeric equivalents of outputs from at least two signal interfaces of equipment or of variables in the industrial or commercial process that is to be monitored, controlled, or simulated;

a means for constructing a second group of one or more related screen displays associated with the operation of an industrial or commercial process, which screen displays, called derived views, include visual representations, called output objects, of one or more processing variables or of one or more units of processing equipment in the industrial or commercial process that is to be monitored, controlled, or simulated, which output objects are derived from outputs from analog or digital signal output, or from analog or digital sensor interfaces of equipment or of variables in the industrial or commercial process that is to be monitored, controlled, or simulated;

a means constructing in the derived views one or more visual representations, called input objects, of controllable elements, if any, in the industrial or commercial process that is to be controlled or simulated, which input objects include visual representations of adjustable parameters, called control elements, associated with an analog or digital signal input interface of a controllable element of a unit of equipment or of a computational module in the industrial or commercial process that is to be controlled or simulated;

views in the interactive virtual reality world in three dimensions, and wherein the perspectives in the derived views can be moved by the user through a unit of equipment or through a computational module to display an "x-ray vision" view of the internal aspects of a unit of equipment, of a workpiece being handled, of a feedstream being processed, or a computational process being executed.

29. The system of claim 24, wherein the computer displaying a process overview world, or a computer interfaced over a communications network with the computer displaying a process overview world, includes a means for storing limit values of parameters of a signal output interface, and of detecting and displaying that a parameter of a signal output interface associated with an output object has exceeded one or more limit values, and during periods a parameter of a signal output interface associated with an output object has exceeded one or more limit values, displaying a notice, called an alarm window, that describes each parameter and parameter value that has exceeded one or more limit values, wherein such display is adjacent to the relevant output object in user's display screen or in another part of the user's display screen and is in schematic form, in symbolic form, or as alphanumeric data.

30. The system of claim 24, wherein the computer displaying a process overview world, or a computer interfaced over a communications network with the computer displaying a process overview world, includes a means for computing, and for storing and displaying, the results of root cause analysis of parameters exceeding limit values, and during periods a parameter of a signal output interface associated with an output object has exceeded one or more limit values, the results of computing root cause analysis pertaining to a parameter of a signal

output interface associated with an output object that has exceeded one or more limit values are displayed in schematic form or as alphanumeric data in the alarm window, adjacent to the associated output object, or in another area of the user's display screen.

31. The system of claim 24, wherein the computer displaying a process overview world, or a computer interfaced over a communications network with the computer displaying a process overview world, includes a database containing information about each root cause analysis that is performed and includes a means for displaying a visual representation or alphanumeric data to a user of the computer displaying a process overview world, and upon request from the user to display additional information about the result of a root cause analysis, displays such additional information to the user.

32. The system of claim 24, wherein the computer displaying a process overview world, or a computer interfaced over a communications network with the computer displaying a process overview world, includes a means for predicting that parameters of one or more units of equipment or of computational modules associated with an output object have reached a threshold probability of exceeding limit values, wherein such computer stores and displays the identity of the parameters and the results of the prediction as a visual representation or as alphanumeric data in an area, called a prediction window, adjacent to the associated output object displayed in a user's display screen, or in another area of the user's display screen.

33. The system of claim 24, wherein the computer displaying a process overview world, or a computer interfaced over a communications network with the computer displaying a process

overview world, includes a means for determining unused capacity of one or more units of equipment or of computational modules associated with an output object, and of storing the results of the determination, wherein such computer stores and displays the identity of the parameters involved and the results of the determination as a visual representation or as alphanumeric data in an area, called a capacity window, adjacent to the associated output object displayed in a user's display screen, or in another area of the user's display screen.

34. The system of claim 24, wherein the computer displaying a process overview world, or a computer interfaced over a communications network with the computer displaying a process overview world, includes a means for determining how existing capacity of one or more units of equipment or of computational modules might be used more efficiently, wherein such computer stores and displays the results of the determination as a visual representation or as alphanumeric data in an area, called an efficiency window, adjacent to the associated output object displayed in a user's display screen, or in another area of the user's display screen.

35. The system of claim 22, wherein one series of derived views, called herein a variable interaction world, includes output objects and views in which the output objects are included in a given view based on interdependencies among the variables that the output objects represent.

36. The system of claim 35, wherein the variable interaction world includes:

a means for rendering the derived views in three dimensions, and wherein the user can navigate the user's point of observation to any point within the coordinate space of the variable interaction world and obtain a display of a three-dimensional perspective view from such point of observation;

a means of computing and displaying interdependencies among the variables that the output objects in a view represent,;

visual representations in schematic form, in symbolic form, or as alphanumeric data that show the interdependencies;

a means for storing limit values of parameters of a signal output interface, and of detecting and displaying that a parameter of a signal output interface associated with an output object has exceeded one or more limit values, and during periods a parameter of a signal output interface associated with an output object has exceeded one or more limit values, displaying a notice, called an alarm window, that describes each parameter and parameter value that has exceeded one or more limit values, wherein such display is adjacent to the relevant output object in user's display screen or in another part of the user's display screen and is in schematic form, in symbolic form, or as alphanumeric data; and may include

a means for predicting that parameters of one or more variables in the variable interaction world have reached a threshold probability of exceeding limit values, and for display of the identity of the variables and the results of the prediction as a visual representation or as alphanumeric data

in an area, called a prediction window, adjacent to the associated output object displayed in a user's display screen, or in another area of the user's display screen.

37. The system of claim 35, wherein the output objects in a view within the variable interaction world are included in a given view based on the criticality of the variables represented by the output objects in the industrial or commercial process that is to be monitored, controlled, or simulated.

38. The system of claim 22, wherein one series of derived views, called herein a detailed derivation world, includes output objects and:

a means for rendering the derived views in three dimensions, and wherein the user can navigate the user's point of observation to any point within the coordinate space of the detailed derivation world and obtain a display of a three-dimensional perspective view from such point of observation;

views in which the output objects are included in a given view based on the interdependencies among the variables that the output objects represent;

a means of computing and displaying a calculation or other derivation of the variables associated with the output objects;

visual representations in schematic form, in symbolic form, or as alphanumeric data that show the calculation or other derivation of the variables associated with the output objects;

a means for storing limit values of parameters of a signal output interface, and of detecting and displaying that a parameter of a signal output interface associated with an

output object has exceeded one or more limit values, and during periods a parameter of a signal output interface associated with an output object has exceeded one or more limit values, displaying a notice, called an alarm window, that describes each parameter and parameter value that has exceeded one or more limit values, wherein such display is adjacent to the relevant output object in user's display screen or in another part of the user's display screen and is in schematic form, in symbolic form, or as alphanumeric data; and may include

a means for predicting that parameters of one or more variables in the detailed derivation world have reached a threshold probability of exceeding limit values, and for display of the identity of the variables and the results of the prediction as a visual representation or as alphanumeric data in an area, called a prediction window, adjacent to the associated output object displayed in a user's display screen, or in another area of the user's display screen..

39. The system of claim 22, wherein the system includes:

a data flow coordinator unit for receiving data from at least two data sources;

a data preparation unit for transforming the data into output objects, input objects, and views;

a data rendering unit for presenting each output object, input object, and view in two or three dimensions, as selected by a user, to the user;

a data analysis unit for receiving data from at least one of the data sources and for generating a processed set of data; and

wherein the data preparation unit varies a characteristic of each output object in response to changes in the corresponding data sourced from signal output interfaces of equipment or of variables in the industrial or commercial process that is to be monitored, controlled, or simulated.

40. The system of claim 39, wherein the data flow coordinator unit receives data from a source selected from the group consisting of real time data, delayed data, archived data, or fabricated data.

41. The system of claim 39, wherein the data analysis unit scales the data from a data source and transmits the scaled data to the data flow coordinator for distribution to the data preparation unit.

42. The system of claim 39, wherein the data preparation unit alters a scalar size of at least one output object in accordance with a magnitude of the data from its data source.

43. The system of claim 39, wherein the data preparation unit alters a color of at least one output object in accordance with a magnitude of the data from its data source.

44. The system of claim 39, wherein the data flow coordinator unit receives data from a plurality of sources, and the data is ultimately received by the data preparation unit, which transforms data from the plurality of sources into a plurality of output objects, and the data

rendering unit presents the plurality of output objects in views of at least one world.

45. The system of claim 39, wherein the data analysis unit computes interdependencies of the variables corresponding to output objects in the variable interaction world.

46. The system of claim 39, wherein the data analysis unit calculates limits, and the data and limit information are relayed through the data flow coordinator to the data preparation unit, which places one or more limits upon at least one output object, and the data rendering unit displays one or more limits with one or more relevant output objects.

47. The system of claim 39, wherein in response to a selection of one output object by the user, the data preparation unit obtains data from the data flow coordinator for the selected output object and the data rendering unit displays the data.

48. The system of claim 47, wherein the data rendering unit displays, in addition to a graphic representation of the data, values of the data received from the data preparation unit.

49. The system of claim 47, wherein the data analysis unit receives from the data flow coordinator the data associated with the output object and returns a processed set of data to the data flow coordinator, which forwards the data to the data preparation unit for display by the data rendering unit.

50. The system of claim 39, wherein in response to a selection by the user of one of the output

objects, the data rendering unit displays at least one linkage between the selected output object and at least one other output object.

51. The system of claim 39, wherein the data flow coordinator unit receives the data from at least one of the data sources over a communications link.

52. The system of claim 39, wherein the data flow coordinator unit receives the data from at least one of the data sources over a network.

53. The system of claim 39, wherein the system is for use with a monitored process that is to be controlled and wherein the system further comprises a device for sending a signal to the process to be controlled in response to a user input.

54. The system of claim 39, wherein the system is for use with a monitored process and wherein the data rendering unit provides a three-dimensional representative view of the monitored process.

55. The system of claim 39, wherein the data analysis unit alters a scalar size of at least one output object in accordance with a magnitude of the data from its data source.

56. The system of claim 39, wherein the data analysis unit alters a color of at least one output object in accordance with a magnitude of the data from its data source.

57. The system of claim 39, wherein the data analysis unit links a given output object associated with a dependent variable to output objects associated with other variables upon which such given output object depends.

58. The system of claim 39, wherein the data analysis unit calculates links between a given output object and one or more associated variables, and returns the data and linkage information to the data flow coordinator for forwarding to the data preparation unit and then to the data rendering unit for display of the output object and of the associated linkage information.

59. The system of claim 39, wherein the data analysis unit receives from the data flow coordinator the data associated with a given output object and returns variable limit information to the data flow coordinator, which forwards the data and limit information to the data preparation unit for display by the data rendering unit of at least one output object and the limits associated with each such output object.

60. The system of claim 39, wherein the system is for use with a monitored process and wherein the data rendering unit provides a three-dimensional representative view of the monitored process.

61. The system of claim 39, wherein in response to a selection of a given output object by the user, the data preparation unit obtains data received from the data flow coordinator for such given output object and the data rendering unit displays the data.

62. The system of claim 39, wherein the data rendering unit displays values of the data from the data source associated with the output object.

63. A system of computer generation of an interactive virtual reality world for monitoring and controlling a process that is physical or computational, comprising:

a means for constructing a raw data world;

a means for constructing a process overview world;

a means for constructing a variable interaction world;

a means for constructing a detailed derivation world;

a means for providing a user with a means of navigating the collection of worlds by selecting an output object and following the output object's links to other worlds, or by selecting an input object and following the input object's links to other worlds;

a means for displaying views in the other worlds; and

a means for enabling the use to drill-up, drill-down, and drill-across through worlds.

64. A system for conveying information to a user through a display of a three-dimensional world, comprising:

a means for receiving data from at least two data sources;

a means for transforming the data from each data source into a three-dimensional graphical object;

a means for presenting each graphical object to the user within the three-dimensional world;

a means for generating a processed set of data from at least one source of data;

a means for transforming the processed set of data into a processed data graphical object; and

a means for presenting the processed data graphical object in the three-dimensional world.

65. The system of claim 22, 23, or 24 used in an integrated manner for training and operations related to the process to be monitored, controlled, or simulated.

66. The system of claim 22, 23, or 24 used in an integrated manner for operations and prediction related to the process to be monitored, controlled, or simulated.

67. The system of claim 22, 23, or 24 used in an integrated manner for training, operations,

and prediction related to the process to be monitored, controlled, or simulated.

68. A system for the computer generation of an interactive virtual reality world for process control comprising a system of claim 22 and one or more other systems for the monitoring, control, or simulation of the process to be monitored, controlled, or simulated interposed between the human or cyber user of the system of claim 22 and the actual process to be monitored, controlled, or simulated.